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MICROSTRUCTURAL CHARACTERISTICS OF 3 AND 5 % CR STEELS FOR ROLLS AND ROLL SLEEVES

(Devoted to the life anniversary of Professor Jonšta and Professor Koštial)

STRUKTURNÍ CHARAKTERISTIKY 3 A 5% CR OCELÍ PRO VÁLCE A BANDÁŽE VÁLCŮ

(Věnovaný životnímu jubileu Prof. Jonšty a Prof. Koštiala)

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Abstract

The paper deals with the problem of hardenability of 3 and 5% Cr steels used for the manufacture of rolls and roll sleeves. The examples of industrial melts show the only slight increase of hardenability when there is an increase of the chromium content from 3 to 5%. This is due to high percentage of undissolved carbides which disturb the real relation to obtained hardness.

Keywords: rolls, roll sleeves, Cr - steels, undissolved carbides

1. Introduction

The effect of chromium content has been studied on the heavy industrial rolls or sleeves, which contained 3 and 5% Cr. For each content has been chosen the optimal austenitization temperature. In the Fig. 1 the IRA diagram is shown which belongs to the origin in Ref. /1/. As shown in this Figure, the increased Cr content has as a consequence the shift of the bainitic nose to the longer transformation times and the lower Ms temperature (the shift from 260 to 220°C). It is supposed, that in 5%Cr steel the amount of Cr in austenite is increased, but at the same time there is an increase of undissolved carbides in the matrix, which partially bound the Cr content.

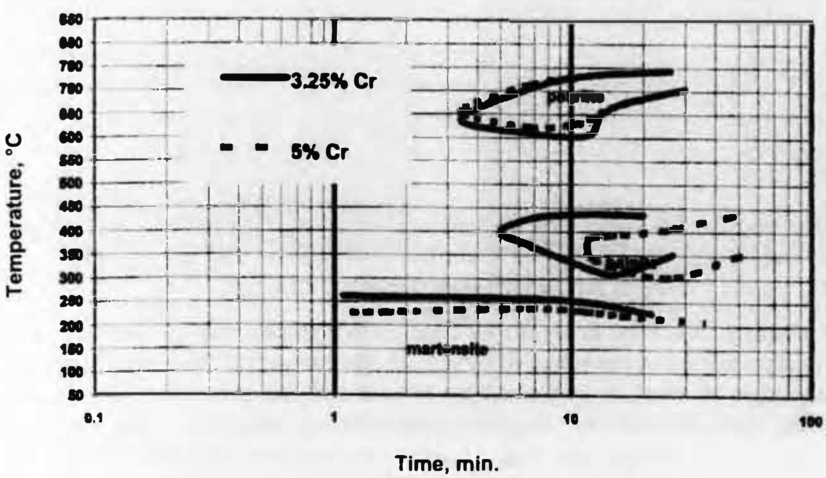

Fig. 1 Diagram ARA of steel with 3 and 5% Cr

To further analysis were chosen two steels with the 3% and 5%Cr. The chemical composition of the steels is shown in the Table I /2/.

Table 1 Proposed chemical composition of 3 and 5% Cr steels

Steels	C	Mn	Si	P	S	Ni	Cr	Mo	V
3%Cr	0.38	0.50	0.30	max 0.010	max 0.005	max 0.30	2.80	0.50	0.08
	0.43	0.70	0.50				3.30	0.70	0.13
5%Cr	0.38	0.50	0.30	max 0.010	max 0.005	max 0.30	4.80	0.50	0.08
	0.43	0.70	0.50				5.30	0.70	0.13

The steels of 3 % Cr content used were of the foreign origin. The 5%Cr steel was made in VÍTKOVICE Heavy Machinery, a.s.

2. Description of results

The experimental material has been taken from the front part of sleeve forgings of the 3% Cr steels (melt A) and from the front part of the roll of 5% Cr steel (melt B). The chemical composition of steels A and B is shown in the Table II.

Table 2 Chemical composition of roll steels

Melt	C	Mn	Si	P	S	Ni	Cr	Mo	V
A	0.43	0.58	0.44	0.009	0.016	0.20	3.32	0.62	0.13
B	0.48	0.40	0.35	0.005	0.002	0.22	5.13	0.61	0.11

In steel the two austenitization temperatures, namely 870 and 930°C, and the quenching to oil have been investigated. They have been connected together with the tempering 530°C/10h (870°C – mark A1, 930°C – mark A2).

In second case the austenitization temperatures remained the same (marking A3 and A4), but to the tempering at 530°C/10h another tempering treatment, 500°C/10h, has been added. After the full heat treatment the hardness HRc and the HV30 have been measured, and the results are concluded in the Table III.

Table 3 Hardness of the roll A

Mark	Ø HRC	Ø HV 30
A1	48	506
A2	49	514
A3	46	
A4	44	

As shown in this Table, the heat treatment with lower and upper austenitization temperature, followed by single tempering at 530°C confirmed the hardness on the required level. In second case of double tempering treatment the hardness has not been sufficient.

The situation has been analyzed by light metallography and by electron microscopy. Fig. 2 shows the microstructure of the actual forging after quenching and the double tempering. In such case the microstructure of steel A is formed by bainite and the prior austenite grain boundaries are invisible. The microstructure of higher austenitisation sample is more defined and the grain boundaries are clearly visible (see Fig. 3). Also the fractographic photos taken from the fracture surfaces demonstrate more toughness on the sample which was heat treated at lower austenitization temperature (compare the fracture surfaces in the Fig. 4 and 5).

Fig. 2

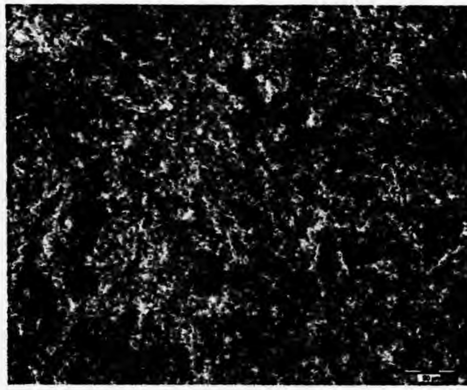

Fig. 3

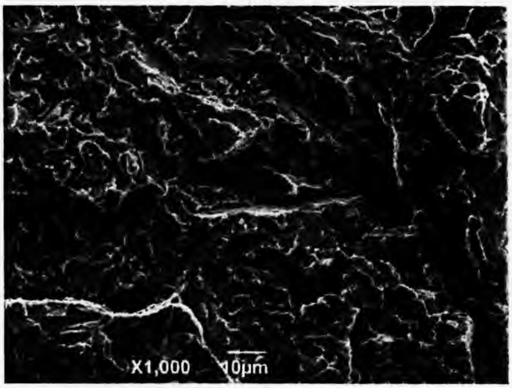

Fig. 4

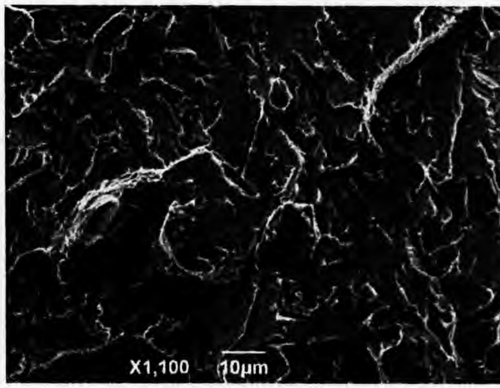

Fig. 5

Even more interesting was the investigation of microstructures and substructures in Steel B. We see e.g. from the Fig. 6 and 7 that the martensitic structure is maybe more acicular, but the same microstructure on carbon replicas show undissolved carbides and tempered carbides which look comparatively as the same, Fig. 8 and Fig. 9 /3/.

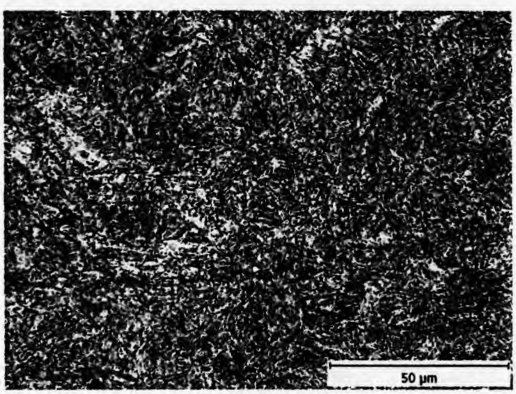

Fig. 6

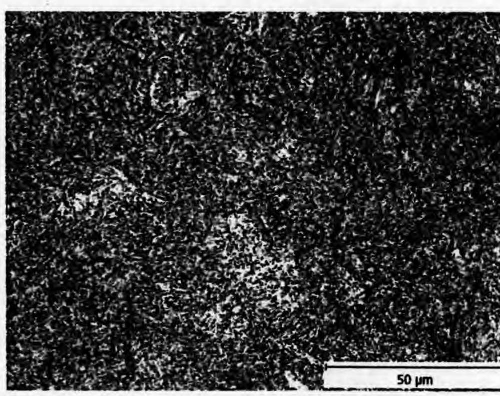

Fig. 7

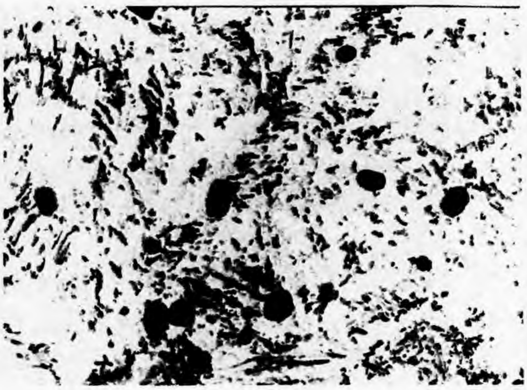

Fig. 8

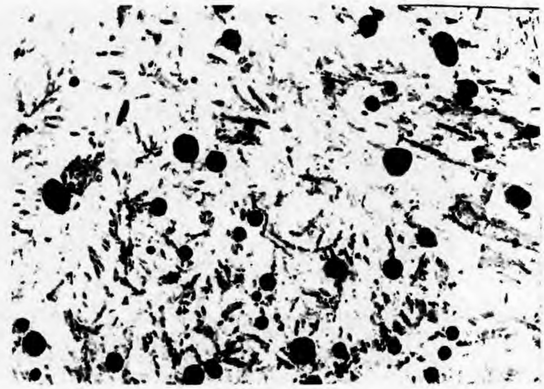

Fig. 9

As very interesting looks the Table IV, where the strength and impact toughness properties are summarized. We see that the tensile strength after tempering at 510° C is at the level of 1880 MPa and this is for the big steel products, as the rolls are, really considerable.

Table 4 Mechanical properties of steel B after various tempering

Sample	Tempering temperature (°C)	R_p 0.2 (MPa)	R_m (MPa)	A (%)	KV (J) (-20 °C)
51	510	1585	1877	8.3	36
52	530	1515	1787	9.6	4
53	550	1409	1631	9.7	30
54	570	1243	1420	10.8	40

3. Conclusions

The 3% and 5% Cr steels are of good hardenability even when produced in heavy weights forgings. As shown by obtained results, in case of rolls and roll sleeves we are able to reach the hardness HRC = 49 and the strength level R_m = 1800 MPa.

Both the 3%Cr and 5%Cr steels are approximately of the same hardenability as visible from the Fig. 1. The reason for that is the partial dissolubility of carbides at the austenitization and this way the retention of the similar chemical composition.

At the tempering temperatures from 510 till 570°C it is the M_3C carbide which precipitates. The presence of M_7C_3 could not be confirmed but at the same time it could not be excluded /4/.

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